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APPLICATION NUMBER: ***60/527,334***
FILING DATE: ***December 05, 2003***
RELATED PCT APPLICATION NUMBER: ***PCT/US04/40760***

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14461 U.S.PTO
120503

PROVISIONAL APPLICATION UNDER 37 CFR 1.53(c)
TRANSMITTAL LETTER

Mail Stop Provisional Patent Application
Commissioner for Patents
P. O. Box 1450
Alexandria, Virginia 22313-1450

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60/527334
120503

Transmitted herewith for filing is the Provisional Patent application of:

Name and Resident Address of Inventor: **JinKook Lee**
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Entitled: **IMPROVED INDUCER FOR PUMP**

Enclosed are: **5** Pages of **SPECIFICATION**;
1 Page **ABSTRACT**; and
4 Sheets of **DRAWINGS** (FIGURES 1-4).

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Respectfully submitted,

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MINNICH & McKEE, LLP

05 December 2003
Date

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CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this **Provisional Application and Transmittal,** and all documents referred to as enclosed therein are being deposited with the United States Postal Service on **December 5, 2003** in an envelope as "Express Mail Post Office to addressee" Mailing Label Number **EL 998014690 US** addressed to **Mail Stop Provisional Patent Application**, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450.

Mary M. Schriner
Mary M. Schriner

Date: December 05, 2003

IMPROVED INDUCER FOR PUMP

Background of the Invention

[0001] This provisional application relates to pumping assemblies, and finds particular application in pumping cryogenic materials, for example, where the pump assembly is immersed in fluid stored in a reservoir or container, such as a transport ship, and is required to pump the fluid from the bottom of the reservoir.

[0002] U.S. Patent No. Re 31,445, the details of which are incorporated herein by reference, is directed to a submersible pump assembly of the type for which the improved inducer was developed. The '445 patent discloses a cryogenic storage system in which a reservoir, storage tank, tank car, tanker ship, etc., includes a casing suspended from an upper closure member or roof. Pipe sections extend from the roof and house a pump and motor unit that is positioned on a floor of the reservoir or storage container. Power is provided through electrical cables and the entire pump and motor assembly is suspended via cable or rigid tubes or pipes.

[0003] A foot plate is provided on the lowermost end of the pump and motor assembly. Disposed inwardly from the bottom end is a flow inducer vaned impeller. As described in the '445 patent, a typical inducer impeller includes plural, circumferentially spaced vanes that extend radially outward from a central hub. This structure is generally referred to as a fan-type inducer. Still other manufacturers use a different impeller configuration such as a mixed flow inducer rather than the four blade fan-type inducer shown in the '445 patent.

[0004] Although known fan-type inducer and mixed flow inducer pumps have been used with some success in pump assemblies of this type, they encounter a problem when used to pump a two-phase medium or fluid (i.e., liquid and vapor). As more air than liquid is drawn into the pump assembly because of the design, a substantial amount of the fluid is left in the reservoir. If liquid natural gas (LNG) is shipped in a transport ship, for example, it is offloaded or pumped to a storage reservoir on shore. Known designs leave approximately four feet of LNG in the base of the reservoir of the transport ship. In other words, the reservoir of the ship is not sufficiently emptied and the transport ship is forced to carry residual LNG from the pumping

station to a remote location where the transport ship is subsequently refilled. It is estimated that costs associated with this undesired retention and needless shipping of residual LNG that is not pumped from the transport container can cost approximately one hundred thousand dollars ($100,000) per year per foot of residual LNG. Accordingly, a need exists for an improved pump assembly and particularly an improved inducer to significantly reduce the amount of residual LNG remaining in the ship reservoir after pump off.

Brief Description of the Drawings

[0005] FIGURE 1 is a longitudinal cross-sectional view of a prior pump disclosed in U.S. Re. 31,445 in which the improved inducer of FIGURES 2-4 can be incorporated.

[0006] FIGURE 2 is a perspective view of the improved inducer illustrating the hub and blade assembly.

[0007] FIGURE 3 is an elevational view of the inducer of FIGURE 2.

[0008] FIGURE 4 is a rear perspective view of the inducer hub and blade assembly.

Detailed Description of the Invention

[0009] FIGURE 2 illustrates an inducer **100**, which as noted above, is a preferred embodiment of an inducer impeller that particularly addresses issues related to pumping two phase fluid, i.e., air and liquid. The inducer of the present invention removes the problems associated with air so that once the pumped medium has passed part way through the inducer the medium is a single phase liquid. This is achieved with the inducer design illustrated in FIGURES 2-4 and described herein. More particularly, a central hub **110** of the inducer includes an opening **112** therethrough to secure the inducer to a drive shaft (not shown) extending from the associated motor. The first end of the hub has a rounded end (i.e., no sharp edges or contours) and a curvilinear conformation that proceeds form the end as best seen in FIGURES 2 and 3, extending both generally radially outward from the shaft and extending axially therealong. The hub extends from a recess **114** formed in the end and curves outwardly to a first generally constant diameter hub portion **116**. Leading edges of first, second, and third helical blades **120a-120c** extend radially and axially outward from the hub - particularly extending from the constant

diameter portion thereof. As will be appreciated, the leading edges **122a-122c** corresponding to each of the blades is circumferentially spaced approximately 120° from the leading edge of the next adjacent blade. The thicknesses of the blades increases or tapers from the leading edges **122a-122c** to a substantially constant thickness over the remainder of the blades represented by reference numerals **124a-124c,** proceeding to respective trailing edges **126a-126c**. As is perhaps best represented in FIGURES 2 and 3, each blade is identical to the other blades and extends circumferentially approximately 180° from the leading edge **122a-122c** to the respective trailing edge **126a-126c**. Each blade has a helical or spiral conformation as it extends circumferentially about the hub and also extends axially from the generally constant diameter portion **116** of the hub toward an enlarged diameter portion of the hub **130** (FIGURES 3 and 4). As will be appreciated, the hub increases in diameter between the first or leading ends of the blades and the second or axially spaced trailing ends thereof. Stated another way, the hub contour is not simply a constant taper, and advantageously does not incorporate any sharp edges over its length.

[0010] Interposed between the three primary blades **120** are splitter blades. The splitter blades are situated to "carry" more flow through the inducer. Thus, by the time flow has reached the trailing end of the inducer, it is being pumped by six blades rather than the three original blades at the inlet end. The primary blades have a greater twist to aid in compressing the vapor and this increased twist also provides greater spacing in an axial direction (i.e., parallel or along the rotational axis) that accommodates the splitter blades. As noted, three splitter blades **150a, 150b, 150c** are provided, one between each of the primary blades. As perhaps best exemplified in FIGURES 2 and 4, leading edges **152** of the splitter blades are circumferentially spaced about 30° from the leading edge **122** of the primary blades. Each of the splitter blades also has a tapering leading edge **152** that merges into a more substantially constant thickness over the remaining circumferential extent of the blade profile. The circumferential extent from the leading edge **152**to the trailing edge **156** of each splitter blade is approximately 150°.

[0011] As is perhaps best illustrated in FIGURE 3, the hub continues to increase in diameter as it proceeds from the leading edge of the blade toward the trailing ends thereof. Where the flow exits each of the primary and splitter blades, however, the hub has a generally constant diameter and a smoothly rounded contour where it terminates at the second end **160**.

The configuration of the hub serves the purpose of a minimum back pressure at the leading edge. This makes it easy for the fluid to be introduced into the blades of the inducer. The high twist angle of the blades serves a compressor-like function, compressing the vapor so that the pumped medium is converted from a two-phase medium of both air and liquid to a single-phase or liquid by the time it exits the inducer. Thus, the blades, as well as the increasing diameter of the hub, provide this compressing action.

[0012] Whereas a fan-type inducer may achieve a vapor-to-liquid ratio (V/L) of 0.2 to 0.3 therethrough, and a mix flow inducer has a ratio of 0.4 to approximately 0.45, the inducer of the present invention has an approximately 1:1 ratio of the vapor-to-liquid (V/L).

[0013] The depth of the blade, i.e., the dimension of the blade measured in a generally radial direction from the hub out to the outer diameter edge of the blade is also quite different in accordance with the present invention. Whereas a mixed flow pump will typically have an increasing blade depth at the outlet than the depth at the leading edge, such is not the case in the present invention. Here, the depth of the blade measured from the hub to the tip is substantially greater at the inlet than at the outlet (see FIGURE 3). The outer diameter of the blade is essentially unchanged from the leading edge to the trailing edge, but since the hub diameter increases from the leading or inlet end to the trailing or outlet end, the depth of the blades decreases over this axial extent. As noted above, this configuration also contributes to the improved vapor-to-liquid pumping ratio of the inducer assembly.

[0014] Incorporating this inducer design into the pump assembly results in a substantial reduction in retained or residual fuel left in the reservoir. Whereas prior arrangements resulted in approximately four (4) feet (1.22 meters) of residual LNG remaining in the reservoir, the subject invention substantially reduces the residual depth to approximately 8 inches or 0.66 feet (0.2 meters). With an estimated cost of $100,000 per year per foot associated with transporting the LNG that has not been pumped from the ship reservoir, a substantial savings is associated with the ability to pump off a greater amount of LNG, i.e., to reduce the residual depth of remaining LNG in the reservoir.

[0015] Although the invention has been described with respect to the illustrated embodiments, it is understood that the invention is capable of modification and variation and is limited by only the scope of the following claims.

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IMPROVED INDUCER FOR PUMP

Abstract of the Disclosure

[0016] An improved inducer for a pump assembly includes a set of primary blades and splitter blades to achieve a vapor-to-liquid ratio on the order of 1:1. Minimum back pressure is provided at the leading edge to aid in getting fluid into the blades where the vapor component of the pumped fluid is removed. A hub increases in diameter over the axial extent of the helical blades, thereby resulting in a decreasing depth of the blades between the inlet and outlet of the inducer. A substantial improvement in removing fluid from a storage reservoir is obtained resulting in a substantial savings in shipping costs.

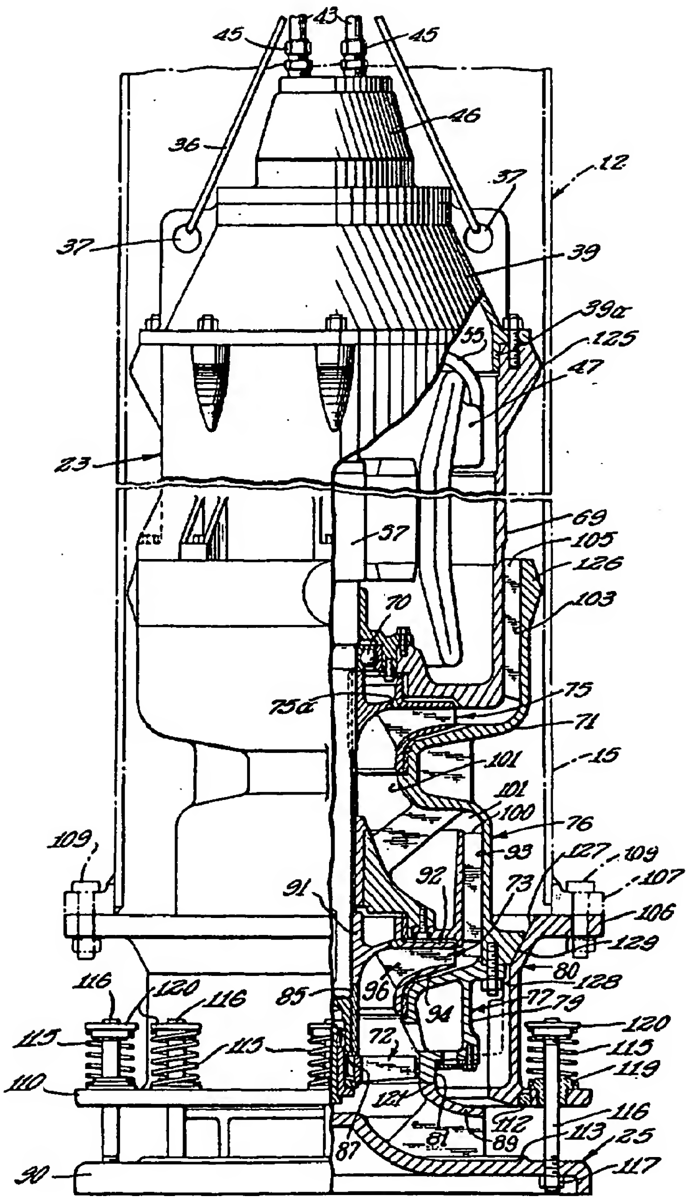
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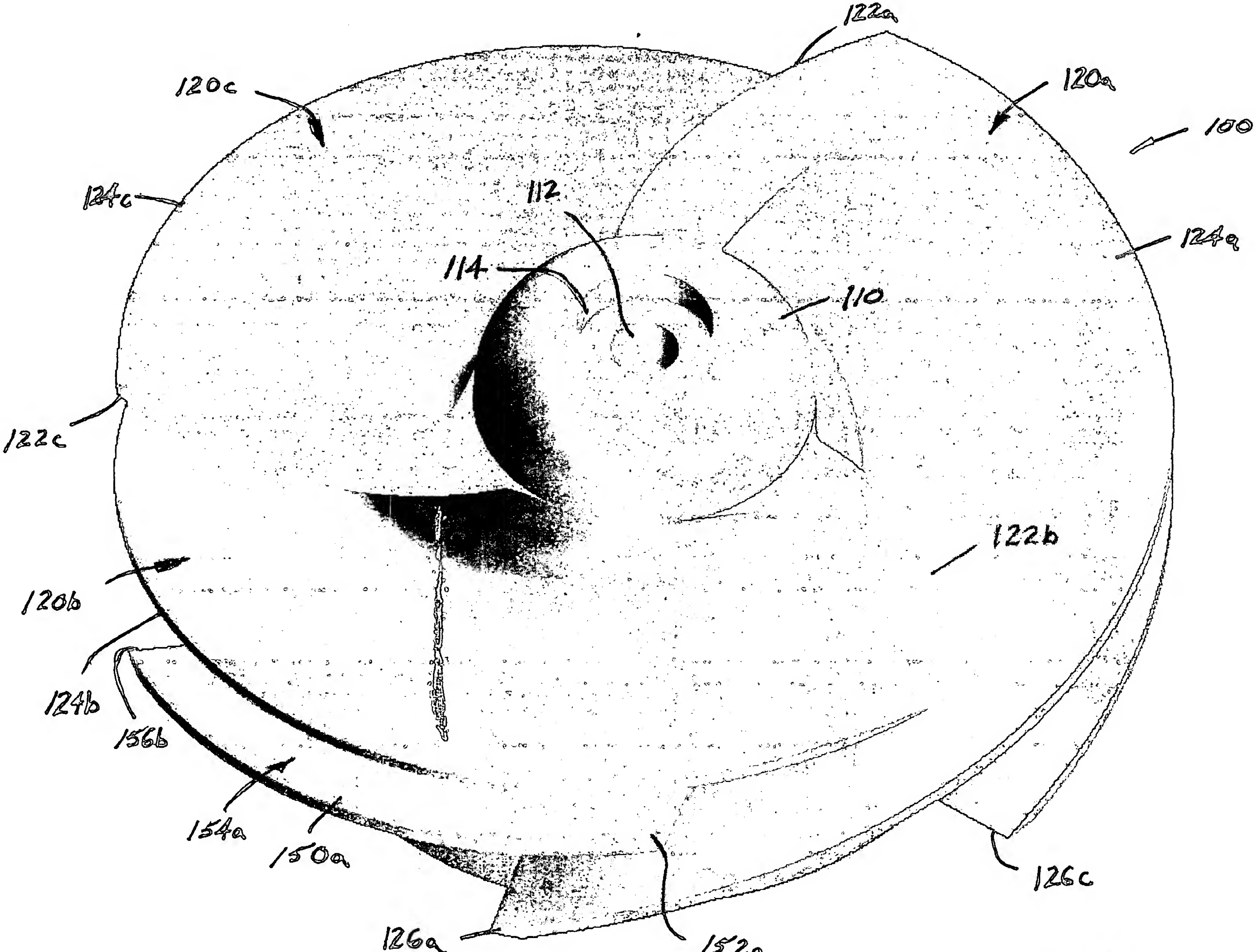
FIG. 1


122a
120c
120a
100
124c
112
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110
122c
122b
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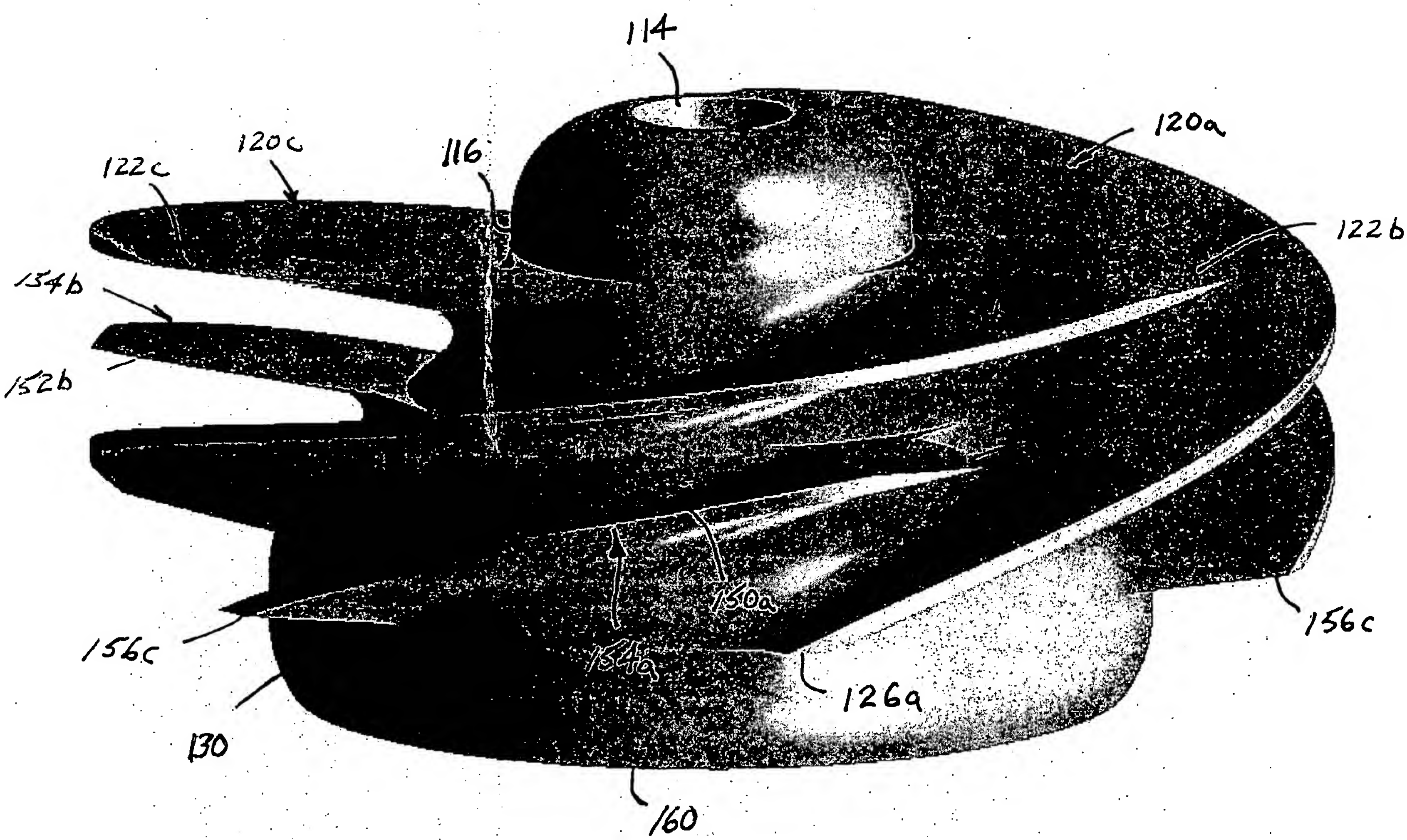
124b
156b
154a
150a
126c
126a
152a
FIG. 2



114
120c
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116
120a
122b
134b
152b
150a
156c
154a
156c
126a
130
160

FIG. 3

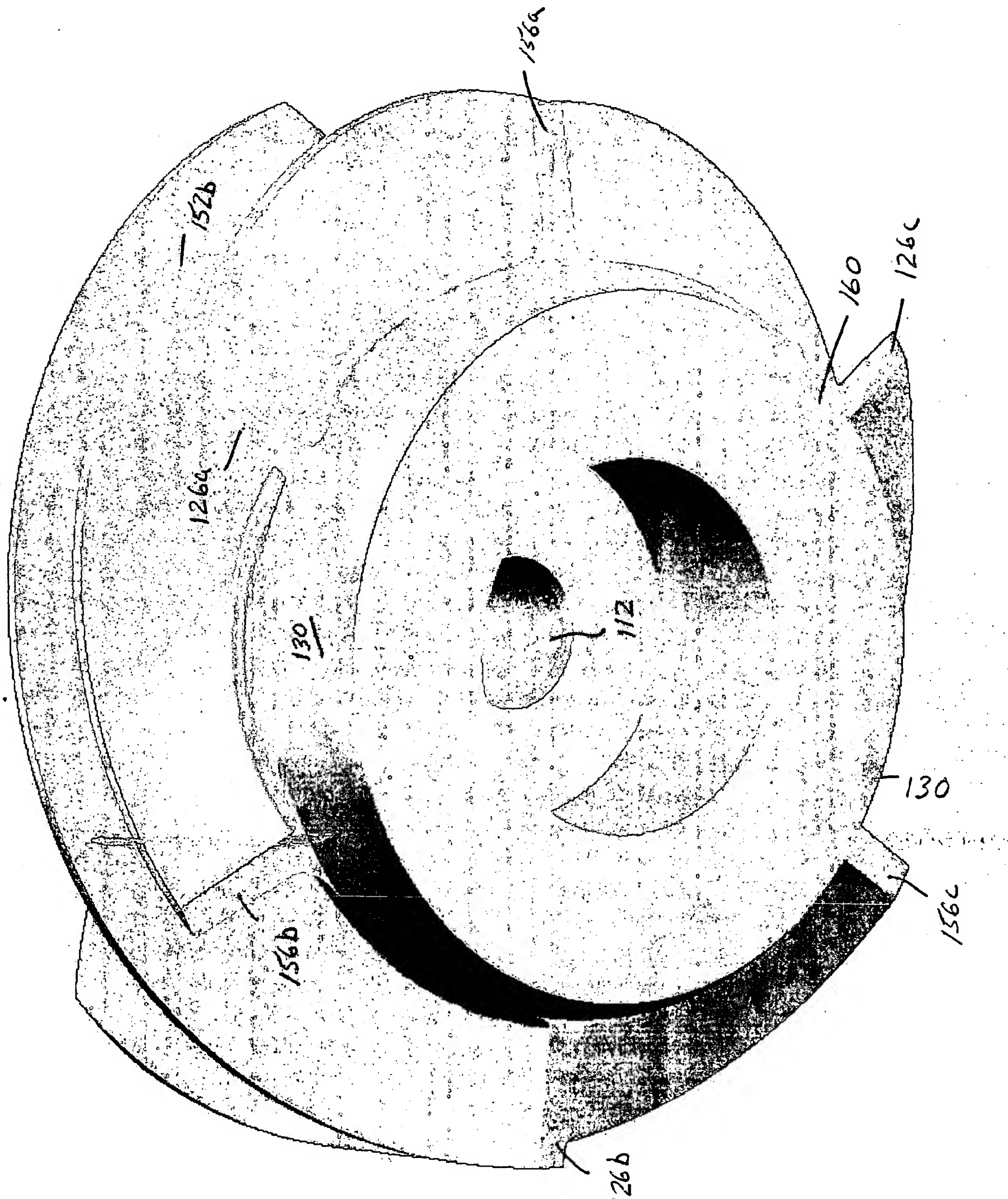

FIG. 4